TIME-LAPSE MODELING AND INVERSION OF CO2 SATURATION FOR SEQUESTRATION AND ENHANCED OIL RECOVERY

Quarterly Report for the Period October 1, 2004 – December 31, 2004

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ABSTRACT

In the fifth quarter of this DOE NETL project, we have implemented an algorithm that inverts for changes in fluid properties over time using time-lapse seismic anomalies. This algorithm constitutes the second step in the inversion procedure for Phase III of our project. We demonstrate this inversion procedure with a synthetic data example. Additional activities in this reporting period include a trip by the Principal Investigator to an International Monitoring Workshop sponsored by the IEA Greenhouse Gas R&D Programme in Santa Cruz, California. In the next quarter, we will further process the Sleipner data to prepare it for later inversion, and continue investigating alternative methods for calculating properties of oil/brine/CO_2 systems.

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I. EXECUTIVE SUMMARY

In this quarter of the DOE NETL project, we have implemented an inversion algorithm that solves for changes in fluid properties over time from time-lapse seismic attributes. This algorithm constitutes the second step in the inversion procedure for Phase III of our project. We demonstrate this inversion procedure with a synthetic data example. Additional activities in this reporting period include a trip by the Principal Investigator to an International Monitoring Workshop sponsored by the IEA Greenhouse Gas R&D Programme in Santa Cruz, California. In the next quarter, the Sleipner data will be further prepared for later inversion, and alternative methods for calculating properties of oil/brine/CO_2 systems will continue to be investigated.

II. EXPERIMENTAL

No experimental methods were used during this reporting period.

III. RESULTS AND DISCUSSION

In this quarter we have continued our algorithm development for the inversion procedure of Phase III. In the initial inversion step, a forward modeling relation is established between the rock and fluid properties of the reservoir and the resulting seismic data. Once this relationship is understood, it can be inverted in the second step to yield the time-lapse changes in fluid properties that correspond to the measured changes in the seismic data. We demonstrate this inversion procedure in Appendix A with a synthetic data example. We also show examples of time-lapse seismic attributes from the Sleipner North Sea CO_2 data set that will be used as input to the real-data inversion.

In addition to this activity, the Principal Investigator attended an International Monitoring Workshop sponsored by the IEA Greenhouse Gas R&D Programme, Santa Cruz, California on November 8-9, 2004. The objectives of the meeting were to bring together the main research groups currently active in the field of CO_2 monitoring, and to review the current state of the art in monitoring technology. Several discussions of the Sleipner project pointed out that current estimates of the injected CO_2 volume obtained from time-lapse seismic traveltime and amplitude changes differ from actual injected amounts, indicating that further study is needed. This observation has stimulated our own research into how such estimates can be improved using our inversion technology.

IV. CONCLUSIONS

In this quarter we have addressed the second step of the inversion algorithm for Phase III of this study, namely, the use of time-lapse seismic anomalies to invert for changes in fluid properties over time. The inversion procedure was demonstrated with a synthetic data example. Additional activities in this reporting period include a trip by the Principal Investigator to an International Monitoring Workshop sponsored by the IEA Greenhouse Gas R&D Programme in Santa Cruz, California. In the next quarter, we will further process the Sleipner data to prepare it for later inversion, and continue investigating alternative methods for generating properties of CO_2 fluid mixtures by equation-of-state (EOS) methods and molecular dynamics modeling.